PERFORMANCE OF RANGE BEEF COWS AS AFFECTED BY SUPPLEMENTAL WINTER FEED AND AGE AT FIRST CALVING

By

DON O. PINNEY

Bachelor of Science

University of Illinois

Urbana, Illinois

1959

Submitted to the faculty of the Graduate School of the
Oklahoma State University of Agriculture and
Applied Science in partial fulfillment
of the requirements for the degree of
MASTER OF SCIENCE
May, 1962

OKLAHOMA
STATE UNIVERSITY
LIBRARY

NOV 8 1962

PERFORMANCE OF RANGE BEEF COWS AS AFFECTED
BY SUPPLEMENTAL WINTER FEED AND
AGE AT FIRST CALVING

Thesis Approved:

L. S. Pope

Thesis Adviser

Glen Bratcher

Robert MacVicar

Dean of the Graduate School

504632

ACKNOWLEDGMENT

The author would like to express his appreciation to Dr. L. S. Pope of the Animal Husbandry Department for his suggestions and help in conducting this research and in preparation of this thesis.

Also thanks are due to D. F. Stephens, Superintendent of the Fort Reno Experiment Station and James Smith, Herdsman, for their help in caring for the experimental cattle and in maintaining various records.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The typical pattern of range cow management in the Southwest involves the grazing of native range grasses year-long, with winter supplementation in the amounts considered necessary to give optimum reproductive performance. Obviously many factors affect this so-called "optimal" winter feeding level, such as: Length of the lactation period before spring grass becomes abundant, species of grasses and amount available, stocking rate, kind and quality of supplemental feed provided, climatic conditions, and the relative costs of cattle and feed.

From an economic standpoint, it is important that we know the relationships between winter feeding level and cow productivity since the cost of winter supplement represents a major part of the operating cost to the cow-calf producer. It should be emphasized that the most economical level of winter supplementation is not necessarily that level which results in maximal cow and calf weights.

The fact that life span can be significantly altered by plane of nutrition has been amply demonstrated with several species of laboratory animals. But the possibility that relatively low planes of winter nutrition for range beef cows may result in a longer productive life has received little attention since few studies have been continued long enough to evaluate long-term effects. It can be seen that any method of lengthening a cow's productive life, without seriously affecting her reproductive performance would be of advantage, since considerable time and cost are involved in rearing replacement heifers.

Two major methods of reducing the cost of rearing replacement heifers are available. In addition to reducing the supplementation of feed, the females may be brought into productivity sooner by breeding them at a younger age. The practice of breeding heifers to calve as two-year-olds has received considerable interest and is not an uncommon practice in purebred herds where heifers are liberally fed. This presents problems, however, under range conditions where heifers are not liberally fed and where little assistance can be rendered at calving time. The lifetime performance of heifers bred to calve as two-year-olds vs. those calving first at three years of age is an important consideration.

To study these specific problems, a project was initiated at the Oklahoma Experiment Station in 1948. The objectives were to determine the accumulative effects of three different levels of winter supplementation and two ages at first calving on the lifetime performance of beef females. One hundred and twenty weanling Hereford heifers were allotted into three groups, with each group to be fed one of three different supplemental feeding levels throughout their productive lifetime. One-half of each of these wintering groups were bred to calve as two-year-olds, whereas the remaining heifers calved first at three years of age. The data presented herein represents individual data accumulated over 13 years, at which time the cows were 13.5 years of age.

REVIEW OF LITERATURE

Much literature is available relative to the effects of level of nutrition on production criteria in several species. Thomas (1952), Shroder (1954) and Zimmerman (1958), in previous summaries of data from this study, have reviewed most of the early literature. Consequently, this review will include primarily the more pertinent or recent literature.

Level of Nutrition

One of the earliest studies on level of winter feeding of beef cows was reported by McCampbell (1920). Eighty heifers were divided into two groups with one group fed liberal amounts of grain and roughage during the winter season, while the other received liberal amounts of roughage only. One-half of the heifers in each group calved first at two years of age; the remaining heifers calved first at three years of age. Although the winter feed level affected weaning weights only slightly, lowered calf crop percentage and a high percentage of nonbreeders were noted in those cows calving as two-year-olds and wintered on roughage only. The author concluded that the beef female never fully recovers from the stress of calving at two years of age, regardless of feeding method, and suggested the rearing of heifers without grain to calve as three-year-olds under range and semi-range conditions.

Withycombe *et al*. (1930) attempted to determine the effects of light or heavy winter feeding, and age at first calving, using 100 Hereford females under range conditions. The cattle were wintered in drylot on various levels of feed ranging from a "light feeding" of alfalfa to a full-feed of alfalfa with "light" amounts of barley. Within each nutritional treatment, one-half of the heifers were bred as yearlings, while the remaining heifers were bred one year later. The results showed that little was to be gained from keeping cows fat and that when fed roughage to the limit of their appetite, they failed to produce as much profit as those fed only two-thirds of a full-feed of roughage.

A study to determine the effects of three planes of winter nutrition on spring-calving beef cows under Oregon conditions was reported by Hubbert and Sawyer (1951). One group of cows received meadow hay, *ad libitum*, during the 130 day winter period; a second group received approximately one-half this quantity of meadow hay; and a third group received hay, *ad libitum*, in addition to 0.9 pounds of barley and 1.2 pounds of cottonseed meal per head daily. All cattle grazed sagebrush-bunch grass range during the summer months and native meadow during the rest of the year. Over a four-year period the lots receiving either the restricted amount of hay, or hay *ad libitum*, weaned significantly smaller calves than the cows fed grain and meal, and also exhibited a 15 percent reduction in percent calf crop weaned. Significant differences in average daily gain of the calves prompted the workers to conclude that the winter nutrition of a range cow, depending upon limited summer forage, has an influence on her milk production.

Patterson (1953) summarized the results of a study on several different methods of wintering bred beef cows under Mississippi conditions. It was shown that the supplementation of a winter ration of dried grass and pasture clippings only with 1.0 pound of cottonseed meal, increased the calf crop weaned by 10 percent, improved calf gains, and consistently resulted in an earlier calving date.

The effects of three different nutritional levels from birth to first calving upon lifetime performance of dairy cows has been reported by Reid et al. (1957). Holstein calves were reared to first calving on levels of 65, 100 and 140 percent of Morrison's feeding standards. After first calving these same groups received 118, 109 and 100 percent, respectively, of Morrison's standards and were all fed 100 percent of these same standards after second calving. At the time of first calving, great differences in body weight, length and height occurred, but the poorly-fed heifers showed remarkable recuperative power in terms of weight and skeletal development after they received sufficient feed. Increasing levels of nutrient intake reduced the age at first heat, although all groups exhibited first heat at near the same body size. Low level heifers had more calving difficulty at first calving and the birth weights of their calves were reduced for the first calf crop, but differed little thereafter. No significant differences in milk production occurred through five lactations.

In a South African study on the influence of winter drought periods on beef and dairy cattle, Joubert (1954) found that cows receiving no winter supplement were significantly retarded in growth as compared to cows receiving supplemental winter feed. Differences in size due to feed level were noted even after four years of age; whereas skeletal development was merely slowed down during the winter period, muscular development actually decreased. A tendency for nonsupplemented individuals to make greater growth during the summer grazing months was noted. The low nutritional plane delayed puberty for more than seven months, decreased birth weights significantly and retarded each subsequent reproductive cycle. The high-plane heifers lost more weight during lactation, presumably due to heavier milk yields, and weaned calves significantly heavier than their low-plane counterparts.

In a study involving seven pairs of identical-twin dairy heifers, Swanson (1960) fed one member of each pair a normal ration of roughage and limited grain while the other was fed heavily on concentrates until first calving to produce rapid growth and fattening. The fattened heifers weighed 32 percent more at two years of age, but produced only 85 percent as much milk during the first and second lactations. Examination of the udder structure of the fattened twins revealed a lack in development of alveolar-secreting tissue. Swanson and Spann (1954) confirmed these results with white rats reared on ad libitum and 80 percent ad libitum amounts of feed. The ad libitum fed rats raised fewer offspring to weaning and weaned litters weighing only about one-half of those of the restricted dams.

Investigations at the San Joaquin, California, Range Station illustrate the advantage of supplemental winter feeding of winter-calving beef cows (Wagnon et al., 1959). The supplemented group of cows received 1.0 pound of cottonseed meal starting in late summer, an additional pound at calving, and an additional pound of barley when winter rains started. This resulted in an increased pregnancy rate of 15 percent, fewer calf losses, an increase of 16 percent in calf crop weaned and an advantage of 58 pounds in weaning weights over nonsupplemented cows. The growth period was longer for the non-fed cows and differences in weight between the two groups were much greater in the spring than in the fall after grazing. Differences in body length and height decreased with age and at maturity were the same for both groups.

Clanton et al. (1960) conducted an experiment with bred yearling heifers to determine the effects of two protein and two energy levels during the winter feeding period. The low energy and protein levels were calculated to provide for maintenance only, while the high energy and protein levels were calculated to provide for 150 percent of maintenance. After calving, all heifers were fed alfalfa hay ad libitum and 3.0 pounds of corn per head daily. Varying the energy level had a significant effect on both body measurements and condition, while varying the protein level had little effect. No significant differences in milk production were found, but the "high-protein high-energy" heifers gave birth to the largest calves and the "high-protein low-energy" heifers weaned the largest calves. The most striking effect noted was the retardation of first heat after calving in all "low-energy" fed heifers.

Williams et al. (1950) conducted a short-term trial to compare the effects of wintering bred ewes on legume hay vs. non-legume hay, with or without approximately 1.0 pound of grain per head daily during the latter half of gestation. These treatments were imposed only during the winter period, and were discontinued at lambing time. Legume hay alone resulted in less weight and death loss of ewes, heavier lambs at birth and more lambs raised as compared to the non-legume fed ewes, and gave results not inferior to those of ewes fed legume hay plus grain.

Utah range studies by Clanton et al. (1959) have shown the difficulty of determining the optimum amount of winter supplement for range ewes. Although supplementation with either a protein pellet, corn or phosphorous increased the wool clip and birth weights of lambs as compared to nonsupplemented ewes, weaning weights and profits differed little between supplemented and nonsupplemented ewes. Specific requirements were difficult to determine as the results were affected greatly by the kind and quality of range forage; the condition, genetic make-up and previous management of the ewes; climatic conditions; and cost of supplement as related to returns from wool and lamb. In a similar study, Van Horn (1959), reported that production differences due to environment were large and that environmental conditions must be considered independently each fall.

The effect of plane of nutrition during the first year of life on lamb and wool production was studied by Bradford et al. (1961). One group of ewes was raised from weaning until the end of the first winter on range grass alone, while another group was reared on legume pasture, alfalfa hay and 0.5 pound of barley for the same period. All ewes were treated identically after the first winter. Range-reared ewes were 25 percent lighter as yearlings and remained lighter throughout the three-year study. The first-year's treatment did not significantly affect lamb production, but number of lambs produced favored the range-reared ewes.

Plane of Nutrition and Life Span

The adverse effects of overweight on the life span of humans is being increasingly recognized and has been demonstrated in several species of laboratory animals. However, research with large animals bearing on this point is extremely scarce. Much data has been reported with laboratory animals, particularly rats and mice, and will be briefly reviewed.

Longevity in any species is determined largely by those forces which hasten or retard the age changes leading to the onset of lesions of the major diseases of the species (Simms and Berg, 1957). It is quite possible that plane of nutrition may be an important variable affecting such changes.

As early as 1917, Osborn et al. noted that female rats which had been nutritionally stunted appeared to live longer and reproduce at an older age than rats which had been fed a normal stock diet.

Hogan (1929) noted the possibility that lower planes of nutrition might be more conducive to longer life. In an experiment involving 10 steers, four steers died before termination of the study and it was noted that those animals fed to gain the fastest were the first to die. Hansson et al. (1953) observed that dairy cows retarded by a low plane of nutrition survived to 95 months of age as compared to 75 months for their high-plane mates. These researchers gave little information on reasons for disposal of the females, but their conclusion that retarded animals have a longer producitve life is in agreement with results of more basic studies.

The earliest study on longevity as related to energy intake per se was reported by McCay et al. (1935). It was found that severe energy restriction of rats up to 766 and 911 days of age resulted in significantly longer life span for the males, but similar life span for females as compared to rats fed normal rations ad libitum. In this study, females were never allowed to reproduce. In an attempt to verify these findings, McCay et al. (1939) reported a further trial in which one group of rats was fed a normal ration while the remaining rats were subdivided and restricted in caloric intake only to 300, 500, 700, and 1,000 days of age. During the retardation phase the rats were allowed to gain only 10 grams during 100-day intervals. As in the first experiment, retardation for periods as long as 300 days resulted in permanent stunting as determined by bone growth and body weight. In each of the retarded groups, some rats were alive when the last of the normal controls had perished.

In a further study, McCay *et al*. (1943) observed that retardation of rats up to 900 and 1,100 days after weaning by allowing only 5 grams of growth every 50 days, increased the mean life span of females 125 days and males 155 days with a mean survival time of 427 days for females and 464 days for males for 900 and 1,100 day restriction, respectively, when compared to control rats receiving the same daily ration but with additional calories in the form of sucrose, milk or liver. Typical animals were sacrificed at various intervals to follow the development of pathological lesions. Rats retarded in growth exhibited a much greater resistance to typical chronic diseases than the rats grown normally, and the development of tumors was largely depressed in the retarded rats; these facts are presented as the major reason for extension of the retarded group's life span. It was noted that while most rats retained the ability to make compensatory growth up to 900 days, only a few did so when retarded 1,150 days.

Ball *et al*. (1947) used littermate mice to determine the effects of restricted amounts of energy on longevity, fertility and growth. Two groups of 74 mice each were used, one receiving a normal control diet, the other restricted to two-thirds the energy intake of the control group. Both diets were imposed shortly after weaning. At 240 days of age the restricted group weighed only one-half that of the controls, but when subsequently full-fed they showed dramatic recuperative capacity and attained the same body weight as their littermate controls in 40 days.

All control mice were fertile up to 240 days while only 20 percent of the restricted mice were able to conceive during this time. But, when full-fed after 240 days, the restricted mice had 13 times as many litters as did their control littermates. It was evident that the restricted mice tended to outlive their littermate controls, even after eliminating deaths due to cancer. There was a zero incidence of cancer noted in those mice restricted for their entire life. Refeeding at 240 days, however, resulted in only a slight increase in longevity as compared to the controls.

French _et al_. (1953) fed diets high in fat (22.7 percent) to rats after weaning and compared this to diets containing only 3.4 and 4.4 percent fat. Although the rats fed the high fat diet consumed about five percent less calories than the other groups and weighed nearly the same, they were significantly shorter-lived. The most marked reduction in life span occurred in the males, but a significant difference also occurred between females. Higher levels of liver fat were found in the "high-fat" group, but no consistent disease or abnormality could be interpreted as a fat-induced cause of premature death. A very similar type of experiment was reported by Silberberg and Silberberg (1954) in which one group of weanling mice were fed a standard stock diet with the fat content raised to 29 percent by addition of lard. These workers found that, in males, the high fat diets decreased life span by 9.1 and 14.3 percent, depending upon the strain of mice, and caused a 50 percent mortality to occur 57 to 123 days earlier than with the stock diet. The life span of virgin females was not affected. Although the groups affected most by the high fat diet tended to be overweight, there was no consistent relationship between body weight and the length of life of individual animals. Hence it was stated that the injurious effect of the high fat diet was at least partly independent of the state of being overweight.

In a rather detailed study, Berg (1960) fed three groups of rats _ad libitum_ vs. 67 percent and 54 percent _ad libitum_ to 833 days of age. This researcher criticized the classical work of McCay _et al_. (1935 and 1943) in that his dietary restrictions were very severe and resulted in great retardation of growth and sexual maturity. Thus, Berg designed this experiment to determine the effects of dietary restriction of a small enough magnitude to still provide for good skeletal growth while preventing accumulation of excess body fat. Although the experiment resulted in 25 and 40 percent reduction in mature body weight of the 67 and 54 percent _ad libitum_ regimes, respectively, much smaller depressions in bone growth were observed. Rats on the restricted diets appeared more sleek in hair coat, had fewer teeth abnormalities and were much more aggressive and responsive to stimuli. On autopsy, large differences were found in amounts of internal fat between restricted and unrestricted rats. Fertility was greatly depressed in the unrestricted females and the few litters that were born in this group were small and weak.

As to their relative life span (Berg and Simms, 1960), it was found that at 800 days of age, only 48 percent of the unrestricted males were alive while 81 and 87 percent, respectively, of the 67 and 54 percent fed groups were alive at this time. At termination of the experiment frequency of lesions in the unrestricted rats was 100 percent as compared to 64 percent for the moderately restricted group, and 24 percent for the most severely restricted group. Although survival rate was not affected in the females, both restricted groups were completely free from disease, whereas 57 percent of the unrestricted females had lesions. Tumor incidence, both benign and malignant, was significantly lower in the restricted animals of both sexes. This study points out the possibility that maximal growth and body size may not be optimal in relation to fertility, longevity and freedom from degenerative diseases.

It is apparent that the majority of the researchers have considered only the quantitative aspects of dietary levels on longevity and have not thoroughly considered the aspects of nutrient balance and nutritional plane simultaneously. The effects of both quantitative dietary restriction and qualitative balance of the diet on the mortality pattern of rats was investigated by Ross (1961). Over 1,000 male rats were divided into eight groups at weaning and received one of four experimental diets either <u>ad libitum</u> or on a restricted intake basis throughout their lifetimes. The diets studied were high or low amounts of either protein (casein) or carbohydrate (sucrose), and combinations thereof. All rats received adequate vitamins and minerals. The effects of restriction of dietary intake were, in general, more favorable for all length-of-life parameters measured.

Restricting protein alone had little effect, while restriction of carbohydrate intake only enhanced life expectancy. Restricting protein and carbohydrates simultaneously had no pronounced affect in early life, but enhanced life expectancy to the largest degree due to its beneficial effects later in life. When the diets were fed on an unrestricted basis, little affect could be seen in terms of life expectancy with the exception of the group receiving low protein and high carbohydrate which resulted in a voluntary restriction of caloric intake and promoted the longest life span of any of the groups. This study seems to be the first to show that life span may be influenced not only by quantitative dietary restrictions, but also by the protein-energy ratio of the diet.

Age at First Calving

Information of the effect of age at first calving on future productivity of beef cows is limited. However, several studies, some involving sheep, are worthy of review.

As previously mentioned, McCampbell (1920) studied the effects of two- and three-year-old calving in beef females and was led to believe that the heifer never fully recovers from the stress of two-year-old calving in terms of future productivity or mature body weight. Heifers wintered on roughage only and calving at two years of age showed a 30 percent reduction in calf crop as compared to grain-fed heifers. In addition, 30 percent of all heifers calving as two-year-olds became nonbreeders, regardless of nutritional treatment. Reed et al. (1924) however, found no injurious effects from calving Holstein heifers at 24 months as compared to 30 months in terms of milk-producing ability, although those cows calving at 24 months of age did not develop as well in terms of body weight or skeletal measurements.

Withycombe et al. (1930) studied the effects of early calving under five different levels of winter feeding. Their results conflicted with those of McCampbell (1920) in that no sterile cows resulted from calving at two years of age. Two-year-old calving resulted in a reduced calf crop at second and third calving, but equal calf crops thereafter, as compared to those cows calving as three-year-olds. While birth weights and gains of the first calves were slightly reduced in those calving at two years of age, they differed little thereafter when comparing both groups at the same age. Mature body weights were reduced for the two-year-old calvers, but this was not reflected in their productivity. At six and one-half years of age these cows had produced 0.7 calf more than those cows calving first at three years of age.

Using sheep, Bowstead (1930) compared first breeding of ewes as lambs vs. yearlings. Lamb breeding did not reduce mature weights of the ewes, and while the first lambs from those bred as lambs were small in both size and number, such ewes out-produced the later-lambing ewes in subsequent years. More marketable lambs were produced by the earlier-bred ewes when compared to the later-bred ewes at the same age. Briggs (1936) found comparable results in that ewes bred at nine months of age reached and maintained the same mature weight as ewes bred one year later, although it required the early-bred ewes 10 months longer to reach maturity. The early-bred ewes gave birth to, and weaned, lighter lambs the first year, but in subsequent years equalled the later-bred ewes in these criteria. Over the seven-year period the early-bred ewes raised 0.7 more lambs and 31 more pounds of lamb per ewe. However, twice as many broken mouths were observed among the lamb-bred ewes at seven years of age vs. those bred first as yearlings.

Spencer et al. (1942), using a paired experimental design to study age at first lambing in Hampshire ewes, bred one of each pair at nine months and the other at 18 months of age. Conception as lambs resulted in lighter weights for ewes at two years of age but this deficiency was overcome at three years of age. Over a five-year period the ewes bred first at nine months of age raised 15 percent more lambs; little difference in weaning weights between the groups after the first year was observed. Since breeding ewes as lambs resulted in an increase in total lamb production, with only a slight decrease in wool production, they recommended this practice where adequate development of ewe lambs could be obtained.

Cmarik (1953) studied the effect of two- and three-year-old first calving in beef cows to 10 years of age. Little difference in mature body weight was observed in the cows. Over the 10-year period, percentage calf crop weaned and weaning weights favored those cows calving first at three years of age, but total number and pounds of calf per cow favored the two-year-old calving cows. For each cow started on the experiment the two-year-old calving cows weaned 1.22 more calves and 353 more pounds of calf. Using normal culling procedures, approximately 20 percent more cows remained in the group calving first at two years of age at the termination of the study. They emphasized the fact that more calving difficulties were encountered with heifers calving first at two vs. three years of age.

The importance of size and development of the heifer if she is to calve first at two years of age was pointed out by Chambers _et al._ (1953). These workers bred a number of yearling heifers, varying in weight from 380 to 595 pounds. They found that if the lightest one-third of the heifers at breeding time had been removed from the data, two-thirds of the calving difficulty would have been eliminated.

EXPERIMENTAL

In October 1948 a study was initiated with 120 choice Hereford weanling heifers. Of this number, 105 were purchased from Moon Ranch at Mill Creek, Oklahoma; the remainder were procured from the Experiment Station herd. On the basis of body weight, the heifers were allotted to eight lots of 15 heifers each and were randomly assigned to treatments. The heifers were started on experiment at the Lake Carl Blackwell Experimental Range near Stillwater, and were subsequently transferred to the Fort Reno Experiment Station in June, 1949.

Throughout the study all cows grazed comparable native grass pastures (primarily bluestems, Indian and switch grass) year-long, and had free access to a mineral mix of two parts ground rock salt and one part steamed bone meal. From November to mid-April each year, the lots were fed the following amounts of supplement per head daily:

Lots 1 and 2 (Low level) - 1.0 pound of cottonseed cake

Lots 3 and 4 (Medium level) - 2.5 pounds of cottonseed cake

Lots 5 and 6 (High level) - 2.5 pounds of cottonseed cake plus 3.0 pounds of oats

The cows were fed twice their daily feed allowances on alternate days. Lot 7 and 8 females were wintered at the Medium level, but were also fed certain summer supplements and thyroprotein-containing feeds during the early years of the test. The results of these treatments have been summarized by Thomas (1952) and Shroder (1954). Lots 7 and 8 will be considered in these data only in the comparison of age at first calving.

The heifers in lots 1, 3, 5, and 7 were exposed to bulls during the summer of 1949 and calved first at two years of age, while the remaining lots were exposed a year later (1950) to calve first at three years of age. All lots were pasture-mated to purebred Hereford bulls from May through mid-April each year so that most calves were dropped in February, March and early April. In 1956, hand breeding was practiced during the early part of the breeding season. In 1952, and thereafter, the cows within each lot were divided on the basis of their previous productivity and assigned to breeding groups at random so that sire effect could be minimized.

Body weights were obtained on all cattle at approximately monthly intervals, and various body measurements were taken on those cows remaining at 3.5, 5 and 9 years of age to determine treatment effects on skeletal growth.

Cows were removed from test only in the event they failed to wean calves for two successive years, or due to serious unsoundnesses such as advanced cancer-eye lesions and spoiled udders, or disease conditions which obviously rendered them of no further productive value.

Essentially the management of calves has remained constant throughout the experiment. Bull calves were castrated at six to eight weeks of age, and all calves were dehorned and vaccinated for blackleg and malignant edema at approximately three months of age. No supplementary feed was provided for any calves and all were weaned in early October at approximately 210 days of age.

The data were analyzed statistically according to the methods of Snedecor (1956).

RESULTS AND DISCUSSION

Results obtained from the initiation of the experiment to 1957 were reported in detail by Thomas (1952), Shroder (1954) and Zimmerman (1958). Summarized herein, is the entire study covering nearly 14 years.

For most items, the effects of level of wintering and age at first calving are discussed separately. However, a table summarizing all lots individually is also presented. Data on age at first calving, within level of winter feeding have been pooled, and vice-versa. This is valid if no interaction between these factors occur. Zimmerman (1958) found no evidence of interaction in the productivity data to 1957.

All results are expressed on a non-weighted basis (averages of means are reported) so as to remove effects due to unequal numbers between years or between treatments within a treatment (i.e. age at first calving within a certain level of winter feeding).

Effects of Winter Feed Level

The average body weights taken before and after each winter feeding period (early November and mid-April) are shown in Figure 1. Only those years after which both age-of-calving groups had given birth to their first calves are included. The most apparent observation is that body weights differed greatly between groups following the winter feeding period, while much less difference was apparent in the fall after all groups had grazed lush summer pasture. This trend is also revealed in

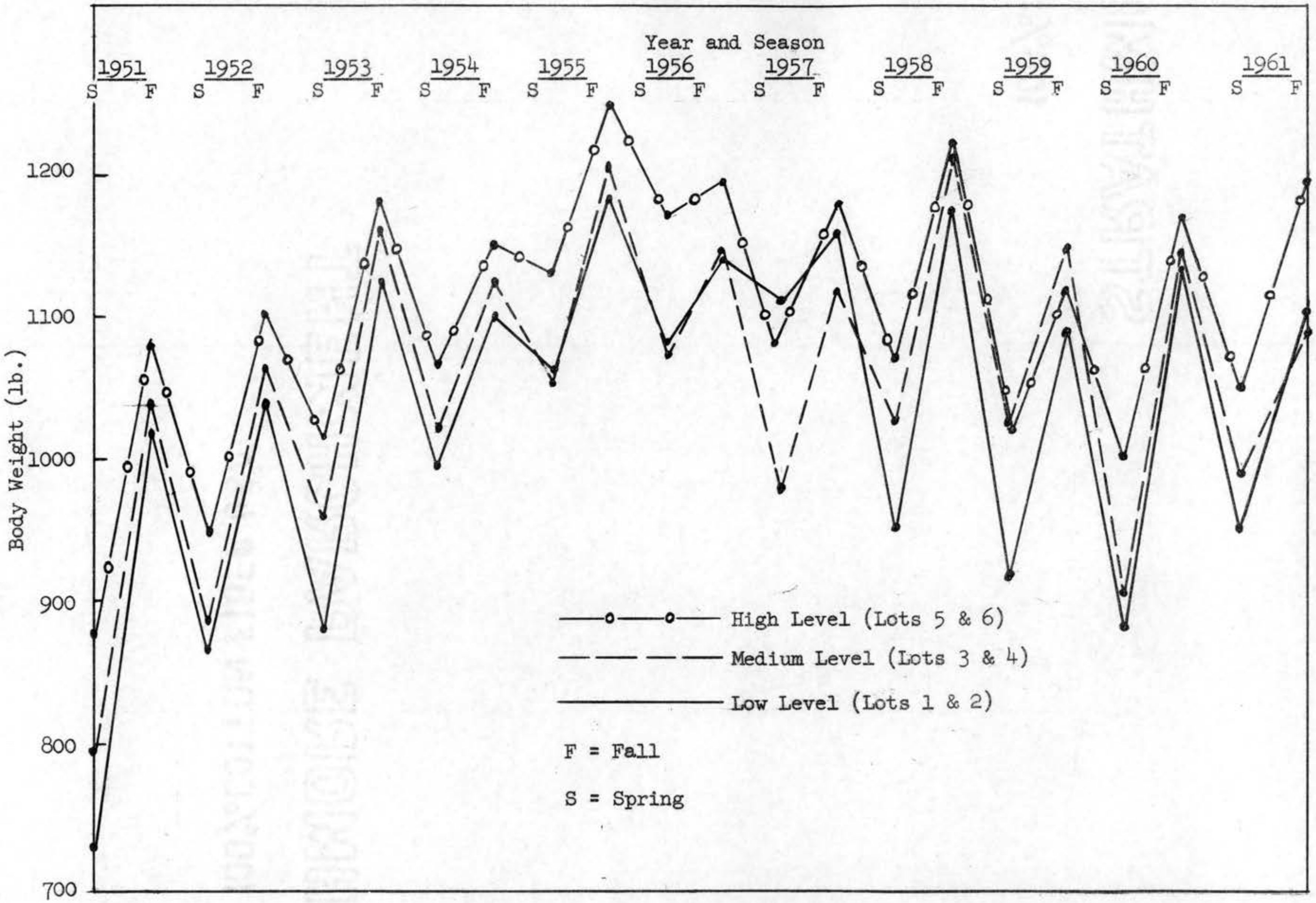

Figure 1. Cow Body Weights as Affected by Winter Feed Level, 1951-1961

Table III. An inverse relationship between summer and winter gains is apparent from these data; those groups losing the most weight during the winter gained the fastest during the remainder of the year. By far the largest differences in body weights occurred in the fall of 1961, but this may not be too meaningful since only eight cows remained in the High level group.

The heaviest fall body weight was attained by the High level females in 1955, at seven and one-half years of age. Both the Low and Medium lots attained their greatest body weight three years later. Presumably, this is a reflection of later maturity. All cows tended to decrease in body weight over the last few years of the study, possibly due to the severe winters during 1957-1959, and loss of condition associated with advancing age.

The excessive loss of weight at the Medium level during the winter of 1956 is unexplainable since all groups were rotated among pastures each winter to minimize differences in forage. With the exception of the period between the spring of 1955 to the spring of 1958, body weight was directly related to wintering level. Much of the differences in weight were probably due to the degree of fatness, since skeletal development at maturity showed less marked differences.

Statistical analysis of the data presented in Table I showed that none of the differences in mature body weights or measurements approached significance, with the exception of width of hooks and pins. In these measurements the Medium level cows were smaller than either the High or Low treatments, which was unexpected. Even though there is an over-all trend for increased magnitude of measurement with increased winter feeding, the accuracy with which the measures approximate actual skeletal development is questionable due to the influence of fatness.

TABLE I

MATURE BODY WEIGHTS AND MEASUREMENTS AS AFFECTED BY WINTER FEED LEVEL[1]

Lot Number Level of Winter Supplement	1 & 2 Low	3 & 4 Medium	5 & 6 High
Body weight (lb.)[2]	1142	1147	1194
Body measurements (in.)[3]			
Width of loin	11.82	12.00	12.16
Width of hooks*	21.35	20.67	21.77
Width of pins*	12.65	12.06	12.62
Heart girth circumference	74.50	74.24	75.64
Height of withers	46.08	46.16	46.56
Depth of chest	26.66	26.38	26.69
Chest to ground	19.48	19.91	19.80
Body length	58.63	58.12	58.67

[1]This data and that presented in Table IX were analyzed together by methods of Snedecor (1956) for R X 2 factorials with disproportionate subclass numbers.

[2]The fall weight in 1956 was selected as the mature weight because more cows weaned calves in this year than in any previous year.

[3]Loin, hooks, pins, and heart girth measurements were taken directly with calipers, while the other measurements were taken from photographs. Length was measured as the horizontal distance from the shoulder point to the posterior point of the pin-bone. These measurements were taken November 22, 1957 when 27 cows remained in lots 1 and 2; 23 in lots 3 and 4; and 21 in lots 5 and 6.

*$P < 0.05$.

Analysis of body measurements from these cows at 3.5 and 5 years of age, given by Shroder (1954), revealed that differences in body length were highly significant, whereas height of withers differed significantly at 3.5 years, but not at 5 years of age. It is widely accepted that height is an earlier maturing part of the skeleton, while length represents a later maturing region, which may offer an explanation for these results.

It would seem from these results, and from those reported in Table I, that the development of the beef female under the conditions of this experiment is affected by the nutritional level in the early stages of growth, but that the propensity for growth is great enough to largely offset this by the time maturity is reached. One could conclude that lower levels of winter feeding delayed maturity, but that skeletal growth differed little when all groups had reached maturity.

The largest difference in mature weight (Table XVI) existed between the Low level cows calving at two years of age (lot 1) and the high level cows calving at three years of age (lot 6). Thus, it seems that two-year-old calving combined with lower winter feeding may result in more severe retardation of growth, as indicated by differences in body weight.

Measurements taken from carcasses of cows which were slaughtered upon removal from test are shown in Table II. Since these were taken only on those cows removed after 1956, it is presumed that all cows had reached a mature skeletal size at this time. In general, the only consistency in the measurements obtained is the smaller dimensions of the Medium level cows, except for pelvic cavity measurement "A". Since there is no reason to believe this should be a real effect due to feed level and because all differences were small, especially between the Low and High groups, it might be concluded that plane of winter nutrition had little, if any, effect on mature skeletal size.

The winter and summer weight gains of the cows are given in Table III. During the first winter (171 days) as weaner calves, average daily gains were 0.13, 0.35 and 0.51 pounds for the Low, Medium and High groups, respectively. As was the case throughout the trial, there was an inverse relationship between winter and summer gain when all heifers had access to lush native grass. Somewhat surprising, however, is the slight difference between summer gains of the Medium and Low groups.

TABLE II

CARCASS MEASUREMENTS ON COWS CULLED AS AFFECTED BY WINTER FEED LEVEL

Lot Number Level of Winter Supplement	1 & 2 Low	3 & 4 Medium	5 & 6 High
Number of cows	11	13	14
Carcass length (in.)[1]	54.50 ± .24[2]	53.14 ± .24	54.24 ± .48
Length of leg (in.)[3]	29.26 ± .16	28.68 ± .10	29.26 ± .21
Depth of rib cage (in.)[4]	17.98 ± .14	17.54 ± .16	17.83 ± .14
Pelvic cavity (in.)			
A[5]	9.96 ± .13	10.12 ± .11	10.58 ± .14
B[6]	8.90 ± .18	8.68 ± .21	9.10 ± .15
Shank bone (cm.)			
Length	19.72 ± .13	19.62 ± .16	19.82 ± .14
Width	3.88 ± .03	3.74 ± .06	3.84 ± .06

[1]Measured from anterior edge of aitch bone to anterior edge of first rib.

[2]Standard error of mean on a within-age-of-first-calving basis.

[3]Measured from anterior edge of aitch bone to furthest extremity of metatarsals.

[4]Measured from dorsal edge of spinal cord at middle of fifth thoracic vertebrae parallel with floor to ventral edge of sternum.

[5]Measured from posterior end of last lumbar vertebrae to anterior edge of aitch bone.

[6]Measured from dorsal edge of spinal cord at center of third sacral vertebrae to nearest point of aitch bone.

TABLE III

SUMMER AND WINTER WEIGHT GAINS AS AFFECTED
BY WINTER FEED LEVEL

Lot Number Level of Winter Supplement	1 & 2 Low	3 & 4 Medium	5 & 6 High
Number started on test	30	30	30
Initial weight, 10/28/48, (lb.)	476 ± 7.9[1]	476 ± 8.2	476 ± 8.7
Winter gain as calves	23 ± 4.8	60 ± 4.7	88 ± 4.4
Summer gain as yearlings	288 ± 6.6	258 ± 6.0	257 ± 5.8
Winter gain as bred yearlings[2]	-90 ± 15.8	-52 ± 13.5	-26 ± 24.6
Summer gain as two-year-olds[2]	201 ± 14.3	181 ± 15.3	171 ± 14.8
Average winter gain, 1950-1960[3]	-162 ± 4.3	-159 ± 3.9	-115 ± 4.4
Average summer gain, 1951-1961[3]	163 ± 4.2	147 ± 3.6	112 ± 3.6

[1]Standard error of the mean on a within age-of-first-calving basis.

[2]Includes only those lots calving as two-year-olds, lots 1, 3 and 5.

[3]Only those cows calving and raising a calf for any of the particular years are included in the calculation.

Also reported in this table are the following winter and summer gains of bred yearlings and two-year-olds nursing their first calves. The average winter gain of those cows calving for 1950 through 1960 indicates that there was much less difference between the Medium and Low group than between these two groups and the High level treatment. These data represent an average body weight loss of approximately 15, 14 and 10 percent of the fall weight for the Low, Medium and High groups, respectively. Summer gains showed much the same inverse trend as mentioned previously.

Gain to calving is reported in Table IV. These values represent the gain in body weight from the start of the winter period in early November to late January each year. Again, for the first year, and for the average of 1950 to 1960, there is less difference between the Low and Medium groups than between the Medium and High level groups. A part of the differences observed may be due to the earlier stage of gestation of the Low group since they calved an average of five days later than the Medium's and six days later than the High's.

TALBE IV

GAIN TO CALVING AS AFFECTED BY WINTER FEED LEVEL[1]

Lot Number Level of Winter Supplement	1 & 2 Low	3 & 4 Medium	5 & 6 High
Gain to calving as bred yearlings,[2] (lb.)	-16 ± 8.5[3]	-12 ± 8.1	1 ± 6.7
Average gain to calving, 1950-1960, (lb.)	6 ± 1.8	9 ± 1.7	38 ± 2.3

[1]The change in weight from late October or early November to late January. Only those cows calving in each year are included.

[2]Includes only those heifers calving as two-year-olds.

[3]Standard error of the mean on a within age-at-first-calving basis.

The birth and weaning weights, by years, are presented in Figure 2. Birth weights were corrected for sex by the method of Botkin (1952) in which five pounds are added to the birth weight of all heifers. Weaning weights shown here are corrected for sex only, to a steer equivalent. By the method of Botkin (1952), 24 pounds are added to the age corrected weaning weights (210 days) of heifers. Assuming this difference to be directly related to age, a correction factor for sex only was devised as follows:

$$\frac{\text{actual weaning age x 24}}{210}$$

This value was calculated for each heifer, and then added to her uncorrected weaning weight to approximate the sex corrected weaning weight (steer equivalent) basis.

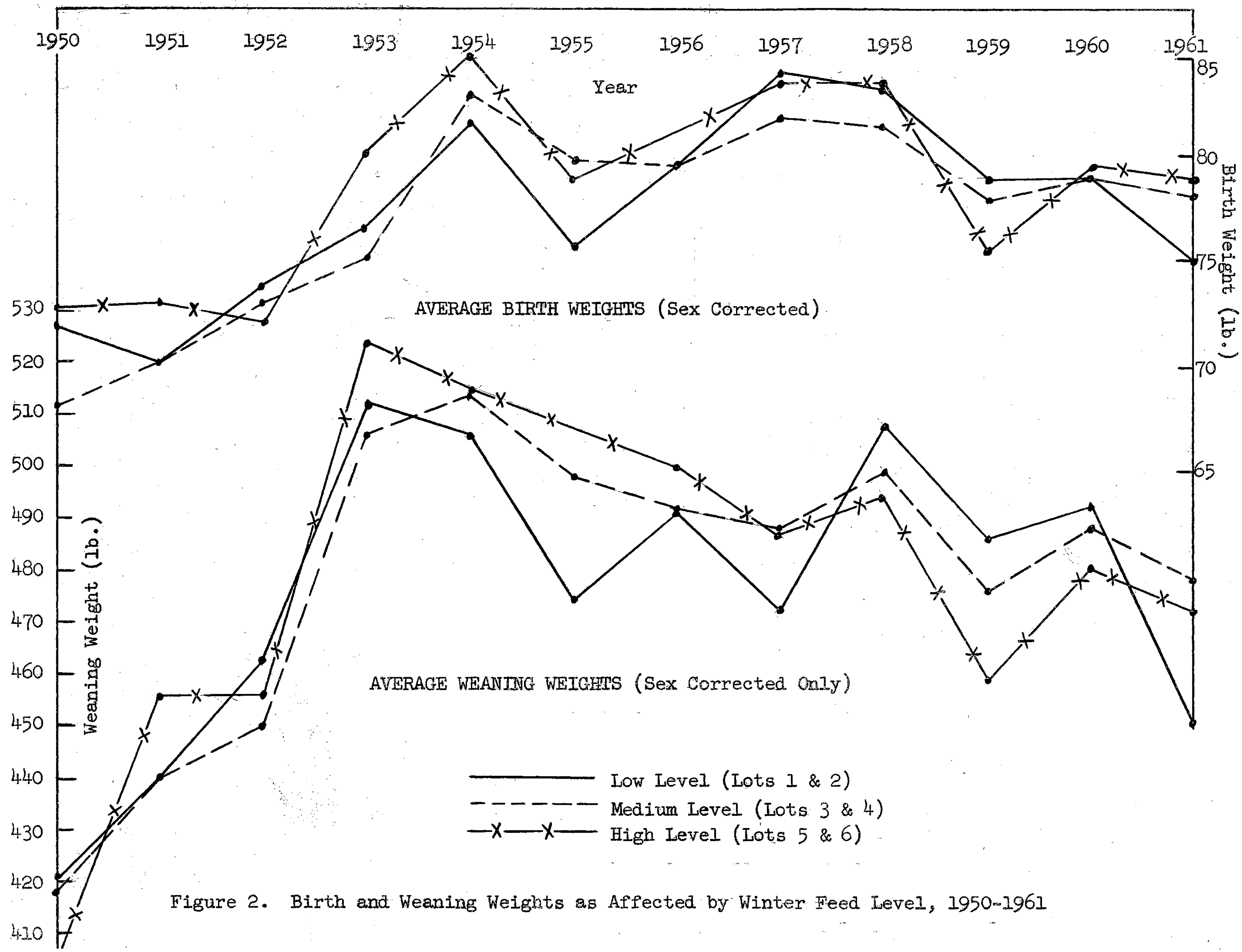

Figure 2. Birth and Weaning Weights as Affected by Winter Feed Level, 1950-1961

The most apparent observation from Figure 2 is the great yearly variation in both birth and weaning weights. Even so, the High level group gave birth to the largest calves in eight years out of 12 years. The heaviest weaning weights occurred at five years of age for Low and High groups and a year later for the Medium level females. Low level cows weaned the heaviest calves five of the 12 years and High level cows in six of the 12 years. Low level cows were more erratic in their weaning weights from year to year than the better fed cows. Lantow (1933) observed that beef cows receiving no supplement on New Mexico range were very erratic from year to year in their productivity. Similar observations were reported by Wagnon _et al._ (1959).

Table V summarizes the calving data for cows on the three winter feed levels. The total number of cows bred decreased with increasing

TABLE V

CALVING DATA AS AFFECTED BY WINTER FEED LEVEL, 1950-1961

Lot Number Level of Winter Supplement	1 & 2 Low	3 & 4 Medium	5 & 6 High
Number of cows bred to calve	321	292	266
Number of calves born	304	265	245
Percent cows bred that calved	94.7	90.8	92.1
Average calving date	3/15 ± 1.33[1]	3/10 ± 1.28	3/9 ± 1.43
Average birth weight (lb., sex corr.)[2]	77.6 ± .49	77.6 ± .57	78.8 ± .61
Calf losses (no.)			
Dead on arrival or shortly thereafter	7	11	15
Disease	1	3	1
Accidental	1	1	4
Unknown	3	4	1
Percent calves dropped that were lost before weaning	3.9	7.2	8.6

[1]Standard error of mean on a within year, within age-at-first-calving basis.

[2]Five pounds added to heifer birth weights (Botkin, 1952).

feed level due to the number removed from test through the years. Perhaps of more significance is the percent of exposures that resulted in birth of a calf, dead or alive. It would appear that the Low level females were more consistent breeders, even though the culling procedures used should have tended to prevent this difference since more cows were removed for failure to wean calves in two successive years in the Medium and High groups. The average calving date was delayed for the Low level females, as compared to those in the other treatments. No doubt this is a real effect of treatment, as it was observed consistently, year after year. It is assumed that these cows did not come into heat until later in the breeding season than the better fed cows. Patterson (1953) also noted that successive levels of winter feeding can influence calving dates. Little difference in birth weights occurred, with the exception of the High level which gave birth to slightly larger calves.

Differences in "livability" of the calves present an interesting picture. Disregarding losses due to disease, accidents or unknown causes, 2.3, 4.2 and 6.1 percent of the calves born in the Low, Medium and High groups, respectively, were dead on arrival or shortly thereafter. Thus, in addition to being less consistent breeders, the better fed cows were also less able to give birth to a strong, vigorous calf.

The above mentioned effect is also apparent in Table VI. Here, percent calf crop weaned is reduced by seven percent in the two better fed groups as compared to those cows receiving only 1.0 pound of cottonseed cake daily. Percent calf crop weaned decreased generally with increased winter feed levels in both age-of-calving groups (Table XVI). Much larger differences, however, are seen within the lots calving first at three years of age.

TABLE VI

WEANING DATA AS AFFECTED BY WINTER FEED LEVEL OF THE DAM, 1950-1961

Lot Number Level of Winter Supplement	1 & 2 Low	3 & 4 Medium	5 & 6 High
Number of calves weaned	290	245	223
Percent calf crop weaned[1]	90.3	83.9	83.8
Number of calves weaned per cow year[2]	.80	.74	.73
Average weaning weight (lb.)			
Age and sex corrected[3]	485 ± 2.56	479 ± 2.66	479 ± 3.06
Sex corrected only[4]	479 ± 3.39	482 ± 3.42	483 ± 4.10

[1]Based on the number of cows bred to calve each year.

[2]Based on total number of years spent by all cows in each nutritional group.

[3]Corrected by methods of Botkin (1952) for age (210 days) and sex.

[4]Assuming 24 lb. difference in weaning weight between sexes at 210 days of age and that the difference is linearly related to age.

When weaning weights are corrected for both sex and age at weaning, it is seen that the Low group had a six pound advantage over both Medium and High groups. This advantage is lost when these weights are not corrected for age, due to the later calving date for this group.

A point of major interest which developed in the late years of this study was the long-term effects of feed level on productive life span. From the standpoint of the producer, the "productive life span" is of major interest and a summary of this data appears in Table VII.

As of January, 1962, the number of cows removed from the Low to High groups respectively were 14, 19 and 25 of an original 30 started at each winter feed level. At this time, the average number of years spent on test per cow was inversely related to winter feed level; the Low level cows had spent over two years longer on test than the High level group, the Medium group being intermediate in this respect. Of the 58 cows removed from this test, nearly one-half were culled for failure to wean a calf for two successive years, with the Low groups accounting for only six of this number. Cancer eye was the next major reason for removal, being more prevalent in the two better-fed groups as was spoiled udders. The increase in cancer eye with increasing feed levels was confirmed by studies of Anderson (1959) on these same cows; he found clinically diagnosed cancer in three, nine and 16 percent of the Low, Medium and High levels, respectively. This correlated well with studies on effect of energy level intake on the development of carcinomas in rats and mice (McCay et al., 1943; Ball et al., 1947; Berg and Simms, 1960). Lot 5 females were most adversely affected in terms of length of productive life where the cows calved first at two years of age and were wintered on the High level (Table XVI). Plane of nutrition appears to have had much less effect on length of life in those cows calving at three years of age.

Some of the removals or death losses cannot be attributed to the winter feed level, but the numbers removed which were assumed to be caused by other variables were four, two and three for the Low through High groups, respectively, and thus would not change the above interpretations.

The economic advantage of decreasing levels of winter feed in this study are apparent from the summary of data shown in Table VIII.

TABLE VII

PRODUCTIVE LIFE SPAN AND CAUSES FOR REMOVAL OF COWS FROM TEST AS AFFECTED BY WINTER FEED LEVEL, 1948-1962

Lot Number Level of Winter Supplement	1 & 2 Low	3 & 4 Medium	5 & 6 High
Av. no. of yrs. on test per cow[1]	12.73	11.62	10.68
Number leaving test for:			
Failure to wean calf in two successive years	6	9	9
Cancer eye	1	4	5
Spoiled udder	2	1	4
Disease	0	1	2
Accidental	1	0	0
Died at calving	0	0	1
Crippled	1	2	1
Hardware disease	1	0	2
Unknown	2	2	1

[1]As of the fall of 1961.

TABLE VIII

ECONOMIC DATA FOR COWS WINTERED AT DIFFERENT FEED LEVELS ($)

Lot Number Level of Winter Supplement	1 & 2 Low	3 & 4 Medium	5 & 6 High
Total feed and pasture cost	10,602	12,482	15,316
Total value of calves produced[1]	35,543	29,531	27,064
Return from cows sold[2]	1,055	2,315	2,782
Value of cows remaining[3]	3,589	2,259	1,920
Total net return	29,585	21,623	16,450
Net return per cow year[4]	81.25	65.41	53.83

[1]Calculated from average October Kansas City feeder calf prices for each individual year.

[2]Calculated from average monthly Chicago utility grade prices.

[3]Weight of cows remaining October 26, 1961 at $14.50 per cwt.

[4]Net return divided by total number of years spent by all cows on treatment.

Effects of Age at First Calving

Average body weights of the two- and three-year-old calving groups, taken in the fall and spring of each year, are shown in Figure 3. Only the data after the spring of 1951 are shown since the cows calving first as three-year-olds had not given birth to their first calves until this time. Since first calving, there has been a consistent difference in weight in favor of those cows calving first at three years of age, with the exception of the last two years of the study when the number of cows was greatly reduced. Several workers have made similar observations in both cattle and sheep (Reed et al., 1924; Withycombe et al., 1930; Bowstead, 1930; Briggs, 1936). However, Cmarik (1953) noted little difference in mature weight of beef cows bred first at either two or three years of age.

Average body measurements taken at maturity in the fall of 1956 are summarized in Table IX. Although all differences were small and non-significant, those indices of skeletal size favored the later calving cows, with the exception of body length. This may be the least reliable measurement, due to distortion and the difficulties of locating reference points on the photographs. Differences in mature body weight were non-significant, even though this is one of the largest differences in body weight observed during the experiment.

Carcass measurements, shown in Table X, indicate much the same trend, with all differences being small and in favor of the three-year-old calving group, except for carcass length and length of leg.

The average sex corrected birth and weaning weights obtained by years are shown in Figure 4. There was no difference in birth weights of

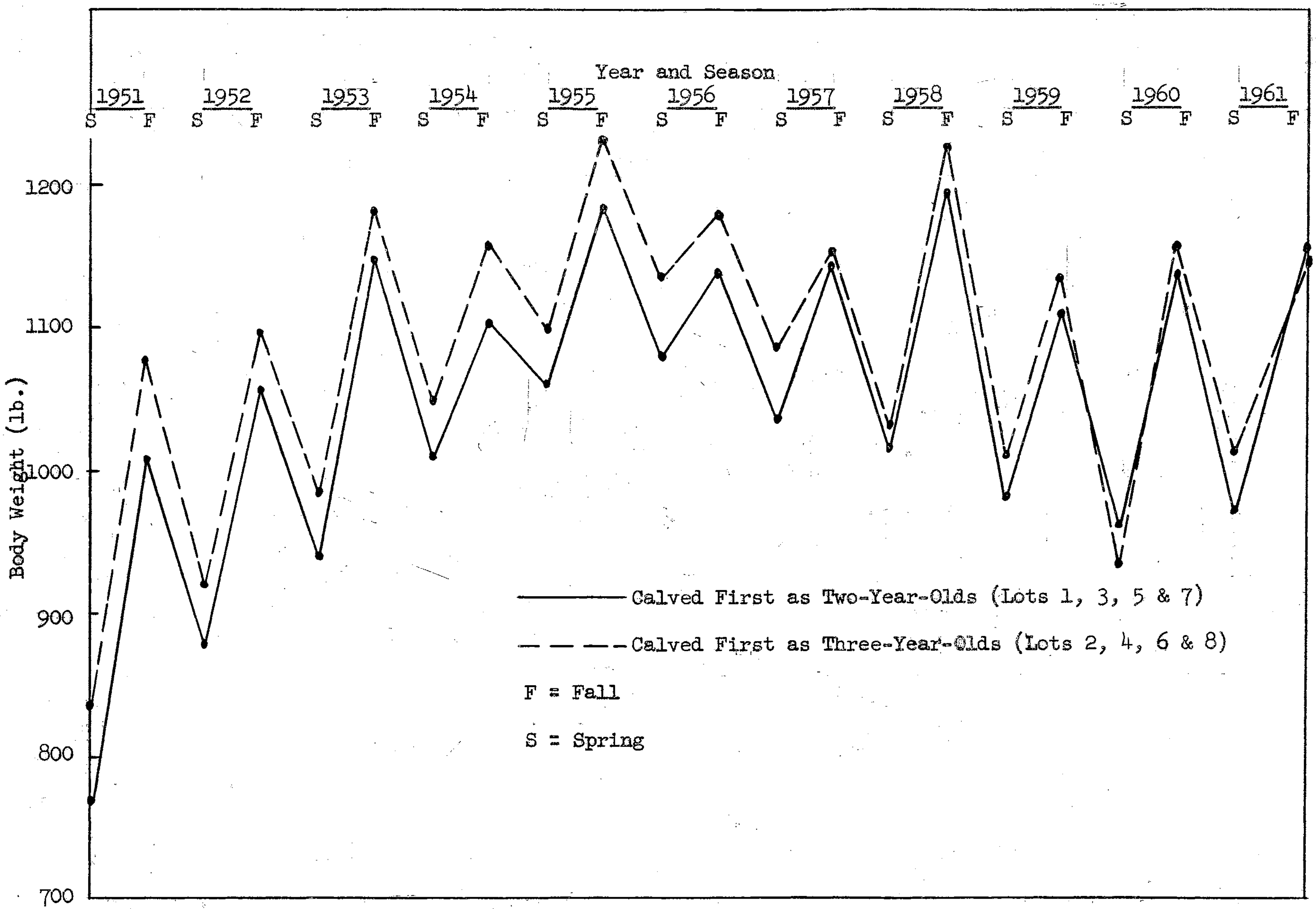

Figure 3. Cow Body Weights as Affected by Age at First Calving, 1951-1961

TABLE IX

MATURE BODY WEIGHTS AND MEASUREMENTS AS AFFECTED BY AGE AT FIRST CALVING[1]

Lot Number Age at First Calving	1, 3, 5, & 7 Two-year-old	2, 4, 6, & 8 Three-year-old
Body weight (lb.)[2]	1148	1178
Body measurements (in.)[3]		
Width of loin	11.85	12.04
Width of hooks	21.20	21.25
Width of pins	12.37	12.53
Heart girth circumference	74.47	75.16
Height of withers	46.03	46.67
Depth of chest	26.40	26.69
Chest to ground	19.68	20.01
Body length	58.46	58.45

[1]See Table I for statistical analysis used and method of measuring.

[2]The fall weight in 1956 was selected as the mature weight because fewer cows failed to wean calves than in any previous year.

[3]As of November 22, 1957, 48 cows remained in lots 1, 3, 5, and 7, while 46 remained in lots 2, 4, 6, and 8.

TABLE X

CARCASS MEASUREMENTS ON COWS CULLED AS AFFECTED BY AGE AT FIRST CALVING[1]

Lot Number Age at First Calving	1, 3, 5, & 7 Two-year-old	2, 4, 6, & 8 Three-year-old
Number of cows	23	28
Carcass length (in.)	53.93 ± .44[2]	53.68 ± .18
Length of leg (in.)	29.17 ± .18	28.97 ± .12
Depth of rib cage (in.)	17.63 ± .13	17.81 ± .09
Pelvic cavity (in.)		
A	10.13 ± .11	10.16 ± .09
B	8.84 ± .13	8.85 ± .12
Shank bone (cm.)		
Length	19.61 ± .10	19.73 ± .09
Width	3.81 ± .04	3.81 ± .03

[1]See Table II for method of measuring.

[2]Standard error mean on a within level-of-winter-feeding basis.

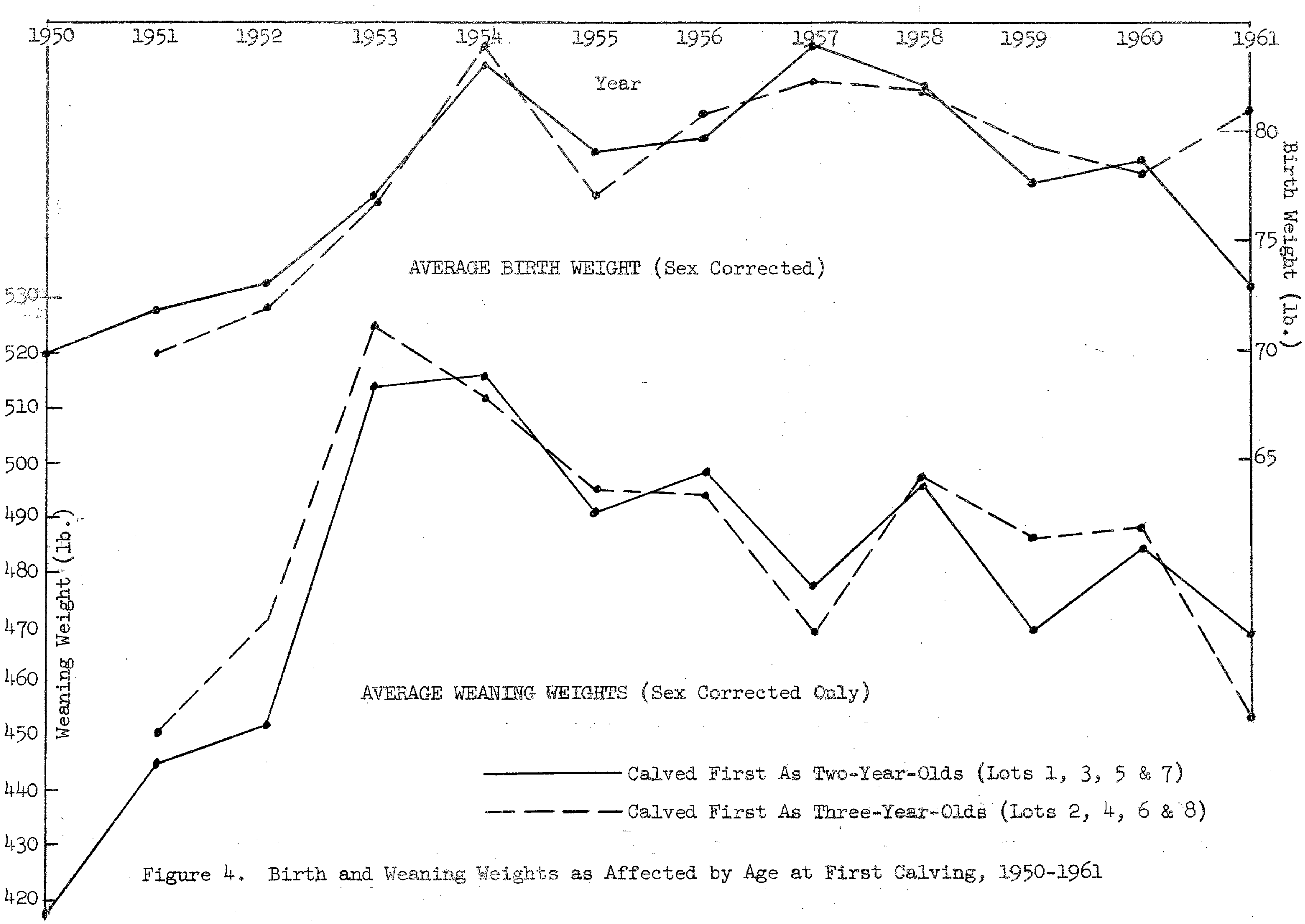

Figure 4. Birth and Weaning Weights as Affected by Age at First Calving, 1950-1961

the first calves, despite the fact that the cows calving at three years of age had an additional year of growth and development before calving. This is rather surprising in view of reports by Withycombe et al. (1930), Briggs (1936) and Spencer et al. (1942). Birth weights during the same year indicate an advantage in favor of the cows calving first at two years of age during their second, third and fourth calf crops, with no consistent differences thereafter. On the other hand, weaning weights of the first calf crop were depressed for the cows calving at two years of age as compared to those cows calving one year later. The two-year-old calving group continued to wean lighter calves through the next three calf crops, but no consistent difference was seen after this time. This effect of early breeding on the first calf crop has been noted by other workers (McCampbell, 1920 and Withycombe et al., 1930) and similarly with early-bred sheep (Bowstead, 1930; Briggs, 1936; Spencer et al., 1942).

Calving data for the two groups are presented in Table XI. It is obvious that calving at two years of age increased calving difficulties. Nearly one-half of the heifers calving at this younger age required assistance at first parturition. The average calving date was unaffected by age at first calving. Birth weights showed an over-all trend in favor of the cows calving first as three-year-olds, but most of this difference is due to the first calf crop from the two-year-old calving group. A larger number of calves were lost at birth from the females calving first as three-year-olds, and this is reflected in the percent calves which were lost before weaning.

Data in Table XII show a higher percent calf crop weaned for the two-year-old calving cows, largely due to a smaller loss of calves at birth.

Average weaning weights, both corrected and uncorrected for age at weaning, show an advantage of nine pounds for the later calving cows. When the first calf crop is disregarded for the cows calving at two years of age however, this difference is reduced to only three pounds.

TABLE XI

CALVING DATA AS AFFECTED BY AGE AT FIRST CALVING, 1950-1961

Lot Number Age at First Calving	1, 3, 5, & 7 Two-year-old	2, 4, 6, & 8 Three-year-old
Number of cows bred to calve	615	566
Number assisted at first calving	28	1
Number of calves born	568	521
Percent cows bred that calved	92.4	92.0
Average calving date	3/11 ± .96[1]	3/12 ± .95
Average birth weights (lb., sex corr.)		
All birth weights	77.3 ± .38	78.3 ± .42
Disregarding first calf crop for two-year-old calvers	78.0 ± .40	78.3 ± .42
Calf losses (no.)		
Dead on arrival or shortly thereafter	17	25
Disease	3	2
Accidental	6	6
Unknown	5	4
Percent calves dropped that were lost before weaning	5.5	7.1

[1]Standard error of mean on a within level-of-winter-feeding basis.

Little difference has been noted in the number of cows remaining on test between the two groups. As of January 1962, 23 and 24 cows remained on test for the two- and three-year-old calving groups, respectively. Productive life span slightly favored those cows calving first at three years of age (Table XIII). Little difference is apparent as to cause of removal of cows from each group, however. A small increase in the removal of cows due to cancer eye was noted in those cows calving at two years of age.

TABLE XII

WEANING DATA AS AFFECTED BY AGE AT FIRST CALVING, 1950-1961

Lot Number Age at First Calving	1, 3, 5, & 7 Two-year-old	2, 4, 6, & 8 Three-year-old
Number of calves weaned	533	482
Percent calf crop weaned	86.7	85.2
Number of calves weaned per cow year	.80	.71
Average weaning weights (lb.)[1]		
Age and sex corrected	476 ± 1.88[2]	485 ± 2.07
Sex corrected only	476 ± 2.50	485 ± 2.71
Average weaning weights disregarding first calf crop for two-year-olds		
Age and sex corrected	482 ± 1.97	485 ± 2.07
Sex corrected only	482 ± 2.64	485 ± 2.71

[1]See Table VI for methods of correction.

[2]Standard error of mean on a within level-of-winter-feeding basis.

TABLE XIII

CAUSES FOR REMOVAL OF COWS FROM TEST AS AFFECTED BY AGE AT FIRST CALVING

Lot Number Age at First Calving	1, 3, 5, & 7 Two-year-old	2, 4, 6, & 8 Three-year-old
Av. no. of yrs. spent on test per cow[1]	11.59	11.88
Number leaving test for:		
Failure to wean calf in two successive years[2]	16	16
Cancer eye	9	6
Spoiled udder	4	5
Disease	1	2
Accidental	0	2
Died at calving	1	0
Crippled	2	2
Hardware disease	2	1
Unknown	2	3

[1]As of fall of 1961.

[2]One cow in lot 4 and one in lot 8 (three-year-old calving group) should have been culled on this basis, but were not.

Economic data accumulated during the experiment are presented in Table XIV. Returns per cow year spent on test were 17 percent greater

TABLE XIV

ECONOMIC DATA FOR COWS CALVING FIRST AT TWO VS. THREE YEARS OF AGE ($).

Lot Number Age at First Calving	1, 3, 5, & 7 Two-year-old	2, 4, 6, & 8 Three-year-old
Total feed and pasture cost	25,125	26,086
Total value of calves produced	64,751	58,274
Return from cows sold	4,210	3,326
Value of cows remaining	4,437	6,345
Total net return	48,270	41,859
Net return per cow year	72.73	61.95

[1]See Table VIII for methods of calculation.

for the early calving cows. This points up the monetary importance of breeding beef females at an early age in order to decrease rearing costs. It should be emphasized that the cows in this experiment received close attention at first calving, thus death losses due to calving difficulties were kept at a minimum.

To determine whether or not the removal of certain cows for reasons already mentioned affected the results of this study in terms of weaning weights for the various lots, the data in Table XV were compiled. This table includes all cows on which productivity data were available and which had been culled or died through the fall of 1960. Presumably, if a predominance of the better producing cows, or vice-versa, were removed from individual lots, this could affect the results and conclusions drawn concerning weaning weight productivity. These calculations indicate that removal of cows from test has not greatly biased the over-all weaning weight data.

TABLE XV

COMPARISON OF WEANING WEIGHT PRODUCTIVITY OF COWS REMOVED FROM TEST WITH PRODUCTIVITY OF COWS REMAINING ON TEST

Age at First Calving	Two-year-old				Three-year-old			
Lot Number	1	3	5	7	2	4	6	8
Level of Winter Supplement	Low	Med.	High		Low	Med.	High	
Number of cows removed from test[1]	2	6	11	3	2	6	5	6
Relative productivity of cows removed[2]	103	98	100	97	95	100	100	97

[1]This evaluation includes only cows removed at an age when weaning weight data was available on them. One cow in each of lot 2 and 4, and two cows in lot 5 were removed after their first or second calf so that precise estimates on their productivity was lacking.

[2]The average weaning weight productivity of cows remaining is represented by 100. The average weight of calves weaned by removed cows was compared to the accumulative average weaning weight of cows remaining on test in that particular lot the year each cow was removed from test.

SUMMARY

An experiment was initiated in 1948 with eight lots of 15 Hereford heifers each to study the effects of level of supplemental winter feed and age at first calving upon the lifetime performance of range beef cows. Results to 13.5 years of age are reported. All lots grazed native grass, year-long, and each winter (November to mid-April) received the following amounts of cottonseed cake per head per day: Lots 1 and 2 (Low level), 1.0 pound; Lots 3 and 4 (Medium level), 2.5 pounds; and Lots 5 and 6 (High level), 2.5 pounds plus 3.0 pounds of oats. Lots 1, 3, 5, and 7 calved first at two years of age, while lots 2, 4, 6, and 8 calved first at three years of age. Lots 7 and 8 were wintered at the Medium level, but received additional thyroprotein supplements during the early summers of the study. These females are considered only in a comparison of two-year-old vs. three-year-old calving. Calves were born in February through April and were weaned in early October each year.

Low level cows calving first at two years of age were 120 pounds lighter at maturity than High level cows which calved at three years of age. Only small differences among mature weights were observed in the other lots. Neither winter feed level nor age at first calving greatly affected measurements of mature body size or carcass measurements from cows slaughtered after removal from experiment. However, most measurements were slightly greater for those cows calving at three years of age vs. those which calved first at two years of age. Birth and weaning

weights were little affected by either winter feed level or age of first calving. Although cows on the Low level consistently calved later (7 to 12 days) than those on the Medium or High levels, they had a higher conception rate and lost fewer calves from birth to weaning; this resulted in a seven percent increase in calf crop weaned. Productive life in the herd was inversely related to the level of winter supplement fed, with 16, 11 and 5 cows remaining on test in the Low, Medium and High groups, respectively, at 14 years of age.

LITERATURE CITED

Anderson, D. E. 1959. The influence of environment on cancer eye in cattle. J. Animal Sci. 18:1461.

Ball, Z. B., R. H. Barnes and M. B. Visscher. 1947. The effects of dietary caloric restriction on maturity and senesence, with particular reference to fertility and longevity. Am. J. Physiol. 150:511.

Berg, B. N. 1960. Nutrition and longevity in the rat. I. Food intake in relation to size, health and fertility. J. Nutr. 71:242.

Berg, B. N. and H. S. Simms. 1960. Nutrition and longevity in the rat. II. Longevity and onset of disease with different levels of food intake. J. Nutr. 71:255.

Botkin, Merwin P. 1952. Repeatability of weights and gains in range beef cows. Ph. D. Thesis. Okla. Agr. and Mech. Col., Stillwater, Oklahoma.

Bowstead, J. E. 1930. The effect of breeding immature ewes. Sci. Agr. 10:429.

Bradford, G. E., W. C. Weir and D. T. Torell. 1961. The effect of environment from weaning to first breeding on lifetime production of ewes. J. Animal Sci. 20:281.

Briggs, Hilton M. 1936. Some effects of breeding ewe lambs. N. Dak. Agr. Exp. Sta. Bul. 285.

Chambers, Doyle, J. A. Whatley, Jr. and W. D. Campbell. 1953. Calving performance of two-year-old Hereford heifers bred to bulls of different breeds and types. Okla. Agr. Exp. Sta. Misc. Publ. No. MP-31.

Clanton, Donald C., Lorin E. Harris and John E. Butcher. 1959. Effect of nutrition on the productivity of range sheep. J. Animal Sci. 18:1416.

_______, D. R. Zimmerman and J. K. Matsushima. 1960. 49th Annual Feeders Day Report. Nebr. Agr. Exp. Sta.

Cmarik, C. F. 1953. Personal Communication.

French, C. E., R. H. Ingram, J. A. Uram, G. P. Barron, and R. W. Swift. 1953. The influence of dietary fat and carbohydrate on growth and longevity in rats. J. Nutr. 51:329.

Hansson, A., E. Brannang and O. Claesson. 1953. Studies on monozygous cattle twins. XIII. Body development in relation to heredity and intensity of rearing. Acta Agr. Scandinavica 3:61.

Hogan, A. G. 1929. Retarded growth and mature size of beef steers. Mo. Agr. Exp. Sta. Res. Bul. 123.

Hubbert, Farris, Jr. and W. A. Sawyer. 1951. The influence of winter nutrition on range beef cattle production in Eastern Oregon. Proc. West. Sect. Am. Soc. An. Prod. 2:109.

Joubert, D. M. 1954. The influence of winter nutritional depressions on the growth, reproduction and production of cattle. J. Agr. Sci. 44:5.

Lantow, J. L. 1933. Supplemental feeding of range cattle. N. M. Agr. Exp. Sta. Bul. 185.

McCampbell, C. W. 1920. The effect of early breeding upon range cows. Proc. Am. Soc. An. Prod. p. 12.

McCay, C. M., Mary F. Crowell and L. A. Maynard. 1935. The effect of retarded growth upon the length of the life span and upon ultimate body size. J. Nutr. 10:63.

_______, L. A. Maynard, G. Sperling, and L. L. Barnes. 1939. Retarded growth, life span, ultimate body size and age changes in the albino rat after feeding diets restricted in calories. J. Nutr. 18:1.

_______, L. A. Maynard, G. Sperling, and L. L. Barnes. 1943. Growth, aging, chronic diseases and life span in rats. Arch. Biochem. 2:469.

Osborn, T. B., L. B. Mendel and E. L. Ferry. 1917. The effect of retardation upon the breeding period and duration of life of rats. Science 45:294.

Patterson, Troy B. 1953. Methods of wintering bred beef cows. Miss. Agr. Exp. Sta. Bul. 506.

Reed, O. E., J. B. Fitch and H. W. Cave. 1924. The relation of feeding and age of calving to the development of dairy heifers. Kans. Agr. Exp. Sta. Bul. 233.

Reid, J. T., J. K. Loosli, K. L. Turk, G. W. Trimburger, S. A. Asdell and S. E. Smith. 1957. Effect of nutrition during early life upon performance of dairy cows. Proc. Cornell Nutr. Conf. p. 65.

Ross, M. H. 1961. Length of life and nutrition in the rat. J. Nutr. 75:197.

Shroder, Joseph D. 1954. Further studies on the effects of age of first calving and level of wintering on the productivity of beef cows. M. S. Thesis. Okla. Agr. and Mech. Col., Stillwater, Oklahoma.

Silberberg, M. and R. Silberberg. 1954. Factors modifying the lifespan of mice. Am. J. Physiol. 177:23.

Simms, H. S. and B. N. Berg. 1957. Longevity and the onset of lesions in male rats. J. Gerontol. 12:244.

Snedecor, G. W. 1956. Statistical Methods. 5th Ed. The Iowa State College Press, Ames, Iowa.

Spencer, D. A., R. G. Schott, R. W. Phillips, and B. Aune. 1942. Performance of ewes bred first as lambs compared with ewes bred first as yearlings. J. Animal Sci. 1:27.

Swanson, E. W. 1960. Effect of rapid growth with fattening of dairy heifers on their lactational ability. J. Dairy Sci. 43:377.

________ and F. R. Spann. 1954. The effect of rapid growth with fattening upon lactation in cattle and rats. J. Animal Sci. 13:1032 (Abstr.).

Thomas, Oscar O. 1952. Relation of nutrition and age of first calving to lifetime performance of beef cows. Ph. D. Thesis. Okla. Agr. and Mech. Col., Stillwater, Oklahoma.

Van Horn, J. L., O. O. Thomas, J. Drummond, A. S. Hoverland, and F. S. Wilson. 1959. Range ewe production as affected by winter feed treatments. Mont. Agr. Exp. Sta. Bul. 548.

Wagnon, K. A., H. R. Guilbert and G. H. Hart. 1959. Beef cattle investigations on the San Joaquin experimental range. Calif. Agr. Exp. Sta. Bul. 765.

Williams, S. B., P. E. Sylvestre, J. E. Bowstead, A. H. Ewen, P. I. Myhr, and H. F. Peters. 1950. Supplemental feeding of pregnant ewes. Sci. Agr. 30:1.

Withycombe, Robert, E. L. Potter and F. M. Edwards. 1930. Deferred breeding of beef cows. Ore. Agr. Exp. Sta. Bul. 271.

Zimmerman, J. E. 1958. Effect of different levels of wintering and different ages at first calving upon performance of beef cows. M. S. Thesis. Okla. Sta. Univ., Stillwater, Oklahoma.

A P P E N D I X

TABLE XVI

SUMMARY OF WEIGHT DATA AND CALF PRODUCTION RECORDS OF COWS WINTERED AT THREE FEED LEVELS AND CALVING FIRST AT TWO DIFFERENT AGES, 1948-1961

Age at First Calving	Two-year-old				Three-year-old			
Lot Number	1	3	5	7	2	4	6	8
Level of Wintering	Low	Med.	High		Low	Med.	High	
No. heifers started, 1948	15	15	15	15	15	15	15	15
No. cows remaining, 1962	10	4	1	8	6	7	4	5
Av. no. yrs. on test/cow	12.22	11.42	9.16	11.45	12.05	10.62	11.21	11.16
Av. wt. changes (lb.)								
Initial wt., 10/28/48	473 ± 11[1]	476 ± 12	476 ± 13	481 ± 11	476 ± 12	461 ± 11	470 ± 12	478 ± 13
Av. winter loss[2]	151 ± 5.6	151 ± 5.2	110 ± 6.0	141 ± 6.5	168 ± 6.9	159 ± 5.8	122 ± 6.3	160 ± 7.2
Av. summer gain[3]	167 ± 5.3	158 ± 5.0	119 ± 5.5	153 ± 5.9	161 ± 6.7	139 ± 5.2	111 ± 4.8	146 ± 7.3
Mature wt., 11/2/56	1103 ± 28	1165 ± 32	1164 ± 30	1160 ± 30	1182 ± 22	1128 ± 39	1223 ± 26	1180 ± 32
Calf production records								
No. of calves born	160	148	113	149	144	118	132	126
Av. calving date	3/13 ± 2	3/8 ± 2	3/10 ± 2	3/13 ± 2	3/16 ± 2	3/11 ± 2	3/6 ± 2	3/9 ± 2
Av. birth wt. (lb.)[4]	77.0 ± .7	76.4 ± .7	78.8 ± .9	77.0 ± .7	78.2 ± .7	78.9 ± .9	78.9 ± .8	77.1 ± .9
No. of calves weaned	150	136	105	142	140	109	118	115
Calf crop weaned (%)	88.2	85.0	84.0	88.8	92.7	82.6	83.7	81.0
Av. weaning wt. (lb.)								
Age and sex corr.[5]	478 ± 3.3	481 ± 3.2	467 ± 4.4	479 ± 4.2	492 ± 4.0	477 ± 4.5	491 ± 4.3	478 ± 3.8
Sex corr. only[6]	474 ± 4.2	487 ± 4.4	468 ± 5.8	467 ± 5.6	484 ± 5.3	476 ± 5.3	500 ± 5.7	487 ± 5.1

[1]Standard error of the mean on a within year basis.
[2,3]Includes only those cows raising a calf for any particular year.
[4]Corrected by the method of Botkin (1952) for sex by adding 5 lb. to heifer calves birth weights.
[5]Corrected for age and sex by the method of Botkin (1952).
[6]Corrected for sex only.

VITA

DON O. PINNEY

Candidate for the Degree of

Master of Science

Thesis: PERFORMANCE OF RANGE BEEF COWS AS AFFECTED BY SUPPLEMENTAL WINTER FEED AND AGE AT FIRST CALVING

Major Field: Animal Nutrition

Biographical:

Personal Data: Born in Monmouth, Illinois, September 12, 1937, the son of Merlyn O. and Violet M. Pinney.

Education: Received the bachelor of Science degree from the University of Illinois, with a major in Animal Science in May, 1959.

Experiences: Raised on a farm in Western Illinois; Graduate Assistant in Animal Husbandry at Oklahoma State University, 1959-1962.

Date of Degree: May 27, 1962